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INPUT PARAMETERS FOR CFD FLOW MODELLING OF FORESTED TERRAIN

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Introduction

Siting of wind turbines in forested terrain requires careful assessment of the wind conditions due to the high levels of turbulence and wind shear. This task can be accomplished using CFD (Computational Fluid Dynamics). A RANS (Reynolds-averaged Navier-Stokes) approach where the turbulence closure is achieved with k-epsilon model is often used to model the atmospheric flow. Additional terms depending on the flow and vegetation characteristics are usually incorporated in the momentum equations and in the turbulence transport equations in order to account for plant drag.

Approach

The accuracy of the canopy flow predictions thus relies mainly on the precision of the input parameters of the forest characteristics, most important of which are the forest height h, the leaf area density LAD and the aerodynamic drag coefficient Cd. Unfortunately, the information on such parameters in many areas are notably scarce. The aim here is to present suitable methods for obtaining the canopy parameters and to analyse their accuracy and applicability in a CFD modelling perspective.

Main body of abstract

The example site for the presented work is the Tromnæs beech forest on the Falster island, Denmark, where a forest edge flow experiment took place in 2008 from March to September, thus both the foliated and the bare canopy periods were covered. For forest height estimation, an increasingly common technique is based on airborne laser altimetry, resulting in DTM (Digital Terrain Model) and DSM (Digital Surface Model) products. We compare height estimates derived from the raw data cloud points taken by aerial laser-scans of the Tromnæs forest with in-situ estimates of the stand height, as well as estimates based on the space-shuttle SRTM and satellite ASTER products.

Regarding the density and architecture of the forest, the more easier derived parameter LAI (Leaf Area Index) can be assessed both via in-situ and remote-sensing techniques. At the Tromnæs forest, the LAI was assessed using a Plant Canopy Analyser (Li-Cor Biosciences, Nebraska, USA.) both at the location of the meteorological mast, and for a cross-section through the forest. This technique is based on light transmission within the canopy. From satellite, the MODIS (Moderate Resolution Imaging Spectroradiometer) and Landsat 7 products are available, which can provide LAI estimates at spatial resolutions from 25m-500m and temporal resolutions from 1-2 days. Since in-situ measurements of stand characteristics are typically rare, the satellite products constitute a valuable complement describing both the seasonal and inter-annual variations.

Conclusion

The sensitivity of the model output in terms of wind speed and turbulence to the input parameters is investigated. Tree height and LAI along with observed wind profiles inside the forest are incorporated into the flow model, and this allows us to obtain an estimate of the LAD and Cd parameters. The estimates obtained in this manner will not be relevant only for the Tromnæs forest, but also for other forests with similar tree composition and height.